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BACKGROUND OF THE INVENTION

checked P Fluoromethyl-1,1,1,3,3,3-hexafluoroisopropyl ether,
as described in U.S. Patent Nos. 3,683,092 and 3,689,571, is
a promising new anesthetic for human use which is essentially
non-inflammable, and appears to have few or no undesirable
side effects when administered to humans.

14m In the abandoned patent application Serial No.
771,365, filed October 28, 1978, from which the above two
patents claim priority, several techniques are suggested
which may be used for making ethers having halogen groups in
both of the organic ether substituents, including fluoro-
methylhexafluoroisopropyl ether. It is suggested there that
the corresponding alcohol may be reacted with formaldehyde
and hydrogen fluoride to form the fluoromethyl ether. How-
ever, yields of this reaction generally described in the
abandoned patent application cited above, are not of a de-
sired commercial scale, so other, more cumbersome, multiple
step synthesis routes were initially preferred. Weynmayr
U.S. Patent No. 2,992,276 also teaches the use of parafor-
maldehyde and hydrogen fluoride as a reagent for synthesizing
a fluoromethylether and an alcohol from tetrafluoroethylene.

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In accordance with this invention, a simplified, high
yield synthesis technique for fluoromethylhexafluoroisopropyl
ether is disclosed, capable of producing yields of the de-
sired ether product of the order of 90 percent, with recycling
of unused reactants through the reaction mixture for optimiza-
tion of synthesis. Particularly, fluoromethyl-1,1,1,3,3,3-
hexafluoroisopropyl ether may be made this way as a clinical
anesthetic on a large scale basis.

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DESCRIPTION OF THE INVENTION

P In accordance with this invention, fluoromethylhexa-
fluoroisopropyl ether may be synthesized by adding 1,1,1,3,3,3-
hexafluoroisopropyl alcohol to a mixture containing a stoichio-
metric excess of formaldehyde (preferably paraformaldehyde)
and hydrogen fluoride, plus sufficient sulfuric acid to se-
quester most of the water produced by the reaction. The re-
action mixture is maintained at a temperature of at least
57°C. (which is the boiling point of fluoromethyl-1,1,1,3,3,3-
hexafluoroisopropyl ether) to cause vapor formation by boiling
of the ether product formed. Accordingly, the ether product
which is formed is quickly removed from the reaction mixture
by boiling, which greatly reduces degradation of the ether
product by the strongly acidic reaction mixture.

The vapors of the ether product are then collected and
condensed, for example with conventional distillation equipment,
to collect the impure fluoromethylhexafluoroisopropyl ether pro-
duct. Thereafter, the ether product may be purified, preferably
by a conventional distillation technique, with the hexafluoroiso-
propyl alcohol which is co-distilled with the ether product being
returned, if desired, to the reaction mixture. The deuterium-
containing analog of the above alcohol may be used if desired,
or deuterated formaldehyde, to form a deuterated ether product.

Byproducts of the reaction may also be removed by con-
ventional distillation, or other known purification techniques.

37 38 The term "formaldehyde" as used herein is intended to
include polymers thereof as well as the monomer, such as triox-
ane or the preferred paraformaldehyde.

Preferably, the temperature of the reaction mixture
is maintained at ^B60 to ^F70 degrees, with the hexafluoroisopro-
pyl alcohol being added on a continuous, gradual basis. This

permits the rapid distillation of the ether product, which is rapidly distilled out of the reaction mixture, and the co-distilled alcohol reactant being returned to the mixture after separation from the ether product, until the formaldehyde and hydrogen fluoride reactants become reduced to a concentration insufficient to provide the desired high yields of ether product.

Preferably, at least a 10 to 100 percent molar excess of formaldehyde is present in the reaction mixture, based on the total amount of the hexafluoroisopropyl alcohol added.

Also, at least a 400 to 1000 percent molar excess of hydrogen fluoride is preferably present, based upon the total amount of hexafluoroisopropyl alcohol added.

It is also preferable for a greater weight of generally anhydrous (preferably at least 95 percent) sulfuric acid to be present, when compared with the total weight of the formaldehyde present. Preferably, from 50 to 200 percent greater weight of the generally anhydrous sulfuric acid is present.

It is also contemplated that other ingredients such as solvents, catalysts, diluents, and other materials may also be present in the reaction mixture if desired, as long as the added extraneous materials do not materially change the nature of the reaction described above, but are added to promote the reaction, suppress side reactions, improve the purification step of the synthesis, etc.

ρ The example described below is presented for illustrative purposes only, and is not intended to limit the scope of the invention of this application, which is as defined in the claims below.

OK Example } To 3.0 grams by weight (0.1 mol) of paraformaldehyde there was added 5 ml. of 96 percent sulfuric acid and 10 grams (0.5 mol) of hydrogen fluoride. This reaction mixture was heated to 65°C. Thereafter, there was added on a dropwise basis, over one hour, 13.4 grams (0.08 mol) of 1,1,1,3,3,3-hexafluoroisopropyl alcohol.

During this period, vapors were generated on the dropwise addition of the alcohol reactant, which vapors were collected in a cooled collector of a distillation set over a period of two hours, using the nitrogen sweep technique and apparatus shown in Figure 1 and described below.

Thereafter, the material obtained in the cooled collector at the end of the two hours was quenched on ice, neutralized with ammonia, and distilled.

The material from the cooled collector gave two fractions on distillation. Fraction (1) distilled between 25° and 58°C., to provide a yield of 6.7 grams of material. Fraction (1) was found upon analysis to yield 90 percent by weight fluoromethyl-1,1,1,3,3,3-hexafluoroisopropyl ether, 3 percent by weight of the initial alcohol reaction material, and 7 percent of a formal byproduct, the analysis being by Gas Chromatographic Analysis.

Fraction (2) from the cooled collector distilled between 58° and 95°C. to yield 5.5 grams of material. This fraction contained 11 percent by weight of fluoromethyl-1,1,1,3,3,3-hexafluoroisopropyl ether, 42 percent of the alcohol starting material, 33 percent of a formal byproduct, and 13 percent of an acetal byproduct, the analysis being

again by Gas Chromatographic Analysis.

It appears that the fluoromethyl-1,1,1,3,3,3-hexa-
fluoroisopropyl ether can be obtained in greater than a 90
percent yield, at between 33 and 38 percent conversion,
5 based upon the recovered alcohol reactant from fraction (1).
It is, however, also possible that some water may azeotrope
during the distillation process, which may tend to suppress
the yields. This can be controlled to a significant extent
by the concentration of sulfuric acid present, which can se-
10 quester water that is formed in the reaction.

The recovered alcohol reactant and byproducts are
readily separable from the ether product, and then may be
recycled back to the reaction mixture for the production
of more ether product.

15 *DC* *P* In the drawing, (Figure) 1 is a schematic view of
the reaction apparatus used for performing the reaction des-
cribed above, with further details of the reaction technique
added.

DC *P* Referring to Figure 1, reaction vessel 10, made of
20 Kel-F fluorinated plastic and sealed with closure 12, defines
an inlet line 14 which has a branch connection. One of the
connections 16 is connected to a source of pressurized nitro-
gen gas, and the other connection 18 is connected to a source
of hexafluoroisopropyl alcohol. The reaction vessel 10 is
25 equipped with a magnetic stirring bar 20, and positioned
within an oil bath 22 for control of the temperature of the
reaction mixture at, preferably, about 65°C.

Tubular outlet line 24 communicates with container
10 and carries vapors generated by the reaction mixture 26,
30 which contains the paraformaldehyde, hydrogen fluoride, and

sulfuric acid reactants, to a collector container 28 made of Kel-F fluorinated plastic. Container 28 also defines closure 30 with line 34 sealingly passing through it. Container 28 is also placed in a cooling bath 32 to assist in condensation of the vapors in container 32.

Vent line 34 communicates with the exterior. Accordingly, nitrogen gas may be constantly used to provide a low velocity gas sweep through the reaction system, while the alcohol reactant is added dropwise through inlet line 18. The vapors which are generated leave reaction chamber 10 through line 24, and are condensed in container 28. The sweeping nitrogen gas then continues to pass outwardly through vent 34, while the products and byproducts of the reaction are collected in the collector container 28.

Periodically, the collector container 28 may be emptied of its contents, with the ether product being purified and separated from the alcohol reactant and its byproducts. The reactant and byproducts may be returned to the reaction mixture for further production of the ether product. The byproducts, in turn, tend to suppress the creation of more byproducts in the reaction mixture by the principles of chemical equilibrium. Alternatively, they may be separated for use or further processing.